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PART II
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NAVAL AIR MATERIAL CENTER
NAVAL BASE
PHILADELPHIA, PA.



AERONAUTICAL STRUCTURES LABORATORY
REPORT ON

AIRSHIP STATIC HEAVINESS INDICATOR

ISSUED BY

NAVAL AIR EXPERIMENTAL STATION

NAVAL AIR MATERIAL CENTER
Naval Air Experimental Station
Philadelphia 12, Pennsylvania

In reply refer to:
XT-31-DP:bg
VZPK/F1
(925)

20 AUG 1954

From: Director, Naval Air Experimental Station
To: Chief, Bureau of Aeronautics (AD-221)

Subj: Report No. ASL NAM AD-250.11, Part II, "Airship Static
Heaviness Indicator"

Ref: (a) BUAFR ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952

Encl: (1) Sixteen copies of subject report

1. Inclosure (1) is forwarded for the Bureau of Aeronautics' information and files in completion of the work authorized by reference (a).
2. The equipment for obtaining a direct reading of airship static heaviness has been forwarded to the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, for evaluation and use in accordance with reference (a).
3. With the issuance of this report, the project is considered closed.



Wm. C. DUNN
By direction

BC

REPORT NO. ASL NAM AD-250.11
PART II

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

AIRSHIP STATIC HEAVINESS INDICATOR

BY

AERONAUTICAL STRUCTURES LABORATORY
NAVAL AIR EXPERIMENTAL STATION
NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization BUAER ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952

Dates of Development, Fabrication, and Test . . From 1 Nov 1953 To 20 May 1954

Reported by D. H. Parry Test Engineer
Electronic Scientist

Reviewed by J. Jacobson Section Supervisor
Supv Electronic Scientist

Approved by D. E. Weiss Division Head
Supv Electronic Scientist

Approved by J. S. Keam Head Engineer
Supv Aero Development Engr

Approved by Wm. C. Dunn Superintendent
Commander, USN Aero Struc Lab

DATE ISSUED 10 Aug 1954

REPORT NO. ASL NAM AD-250.11
PART II

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REFERENCES

- (a) NAS, Lakehurst, ltr F1 NA4-70-JCK:cp of 6 Sep 1951
- (b) NAXSTA ltr XT-31-DHP:bg J15-5 (997) of 13 Oct 1953
- (c) BUAER ltr Aer-AC-71 163479 of 22 Dec 1953

PLATES

NUMBER

NAXSTA Photo NA46(1)-282918(L)-5-54 - Completed Strain Gage Installation on Trunnion of Landing Gear	1
NAXSTA Photo NA46(1)-282390(L)-5-54 - Static Heaviness Indicator	2
Portion of Type K SR-4 Indicator Modified for Conversion to Static Heaviness Indicator	3
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ABSTRACT

A prototype airship static heaviness indicator has been developed. Resistance wire strain gages affixed to the trunnion of the type 9060A landing gear measure the vertical shear loads due to static heaviness. The strain gage bridge output is read directly in terms of pounds of static heaviness on a null-balancing type of indicator. The design and operating characteristics of the equipment are described. The equipment has been forwarded to the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, for evaluation and service use.

1.

AUTHORIZATION

The development of an airship static heaviness indicator was authorized by BUAEER ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952. The design, fabrication, installation, and test of the equipment herein described were conducted from 1 November 1953 to 20 May 1954.

2.

OBJECT

To develop a means of providing a direct visual reading of the static heaviness of an airship.

3.

INTRODUCTION

The present method for obtaining the static heaviness of an airship is time-consuming and laborious. It is based on the removal or addition of weights manually to determine the equilibrium condition of the airship. The useful load of personnel, equipment, food, and fuel is then put on board and an estimate of the static heaviness is made which may be as much as ten percent inaccurate. A system for remote indication of the static heaviness of an airship which could instantaneously give more accurate readings in pounds would make possible considerable savings in time and man-power. A resistance wire strain gage bridge, permanently installed to measure vertical shear loads in the trunnion of the type 9060A landing gear manufactured by Cleveland Pneumatic Tool Company, is highly responsive to the static heaviness of the airship. Its output can be indicated at a remote location, providing a straightforward method of obtaining a direct reading of static heaviness.

4.

DESCRIPTION

The system for providing a visual reading of static heaviness consists of a load-sensitive strain gage bridge on the trunnion of the type 9060A landing gear and a Baldwin Southwark type K SR-4 strain indicator modified to give direct readings of static heaviness from zero to 4,000 pounds. The strain gage bridge measures vertical shear load and consists of eight SR-4, type AD-7 resistance wire strain gages in a four-active-arm bridge. The completed and waterproofed installation of the gages on the trunnion is pictured in plate 1. The modified indicator contains balancing and calibrating units in addition to a self-contained, battery-operated power supply. The indicator employs a null-balancing circuit in which motion of a calibrated slide wire varies a bucking voltage to the output of the strain gage bridge. The difference between bridge and bucking voltages is amplified and indicated on an output meter which provides a very sensitive balance indication, independent of battery voltages and tube characteristics. Readings are taken when the output

4.

DESCRIPTION (Continued)

meter indicates zero. Plate 2 is the front view of the static heaviness indicator. Plate 3 shows the modifications in the indicator circuit which provide for direct readings of static heaviness. A drawing of the Baldwin Scuthwark type K SR-4 strain indicator is reproduced in plate 5. A four-conductor shielded cable to connect the strain gage bridge to the indicator is drawn up from the landing gear into the car of the airship.

Before using the equipment, the condition of the batteries should be checked by setting the switch first on "A" and then on "B" and noting on the meter dial whether in each case the pointer is beyond the red range. If not, the batteries should be replaced by removing the cover from the bottom of the indicator case. Turn the power switch to "ON" and allow ten seconds for the warm-up of the tubes. At this point the zero setting should be checked. Turn the "STATIC HEAVINESS - POUNDS" indicator knob to read zero. With no load on the landing strut, i.e., the airship floating with the landing gear off the ground, note the reading on the upper meter. If it is not zero, loosen the "BALANCING" potentiometer lock-nut to permit the shaft to be turned by a screw driver. Rotate the shaft to give a zero reading on the meter and then lock the potentiometer in this position. The airship may now be loaded for take-off. As this is being done, the null-balancing pointer may be kept near zero by rotating the slide wire knob. When the airship is fully loaded, the null-balancing pointer is set exactly at zero by means of the knob. The static heaviness can then be read directly from the lower indicator.

The zero setting of the equipment should be checked prior to at least each of the first twenty take-offs. If no shift is perceptible, the zero determination need not be repeated as frequently. However, it should be checked after any unusually hard landing or other event which could disturb the bridge balance. Perhaps the most convenient time to do this is in flight when there is no vertical load on the landing gear.

The equipment should be re-calibrated about every two weeks. Using known weights or a scale under the landing gear, the indicator may be checked at a number of points up to 4,000 pounds heaviness. First check the zero setting, then load the airship and set the indicator to the applied weight. If the null-balancing meter pointer is not at zero, loosen the "CALIBRATING" potentiometer lock-nut and adjust until pointer is at zero. The shaft is then locked into position.

5.

METHODa. Preliminary Calibrations

In the course of the development, it was found necessary to instrument two landing gears of the type 9^60A. The first was instrumented while installed on the ZP2K-68 airship at the Naval Air Station, Lakehurst, New Jersey. A simple four-strain-gage, four-active-arm bending bridge was affixed to the trunnion. When unsatisfactory calibrations were obtained with this instrumentation, a more complex eight-gage, four-active-arm shear bridge was designed to reduce the large errors previously obtained. This strain gage bridge was installed on the second landing gear at the Naval Air Experimental Station. A loading jig and a loadometer, whose error was less than .5 percent of the full scale of 4,000-pounds static heaviness, were used to calibrate the landing gear. The weight indications were read on the modified SR-4 indicator. Calibrations of a four-gage bridge similar to the original bending bridge were obtained in addition to the calibration of the eight-gage bridge. The calibrations were compared.

b. Field Calibration

After the calibrations on the loading jig, the landing gear was installed on the ZP2K-68 airship for the field evaluation tests. The tests were conducted in the hangar. The loadometer which had been used in the laboratory calibrations was placed under the landing wheel of the airship to give indications of static heaviness. A calibration was run. On the succeeding day the zero shift was checked and another calibration was made.

6.

RESULTSa. Preliminary Calibrations

The unsatisfactory calibrations at the Naval Air Station, Lakehurst, New Jersey, using the simple four-gage bending bridge were due to a shifting of the point of load application on the landing strut trunnion. The errors were large and unpredictable, and tapping of the landing gear mounts produced significant changes in the reading. In the laboratory calibrations, where the shifting point of load application was roughly simulated, the results using the eight-gage shear bridge were greatly improved over those obtained with the four-gage bridge. The errors were reduced to within one percent of full scale of 4,000 pounds, and tapping caused almost no change in the readings.

b. Field Calibrations

The calibration curve is given in plate 4. Differences between static heaviness indication and loadometer readings did not exceed 100 pounds or 2.5 percent of full scale. There was no perceptible zero shift at the start of the second day's calibration.

7.

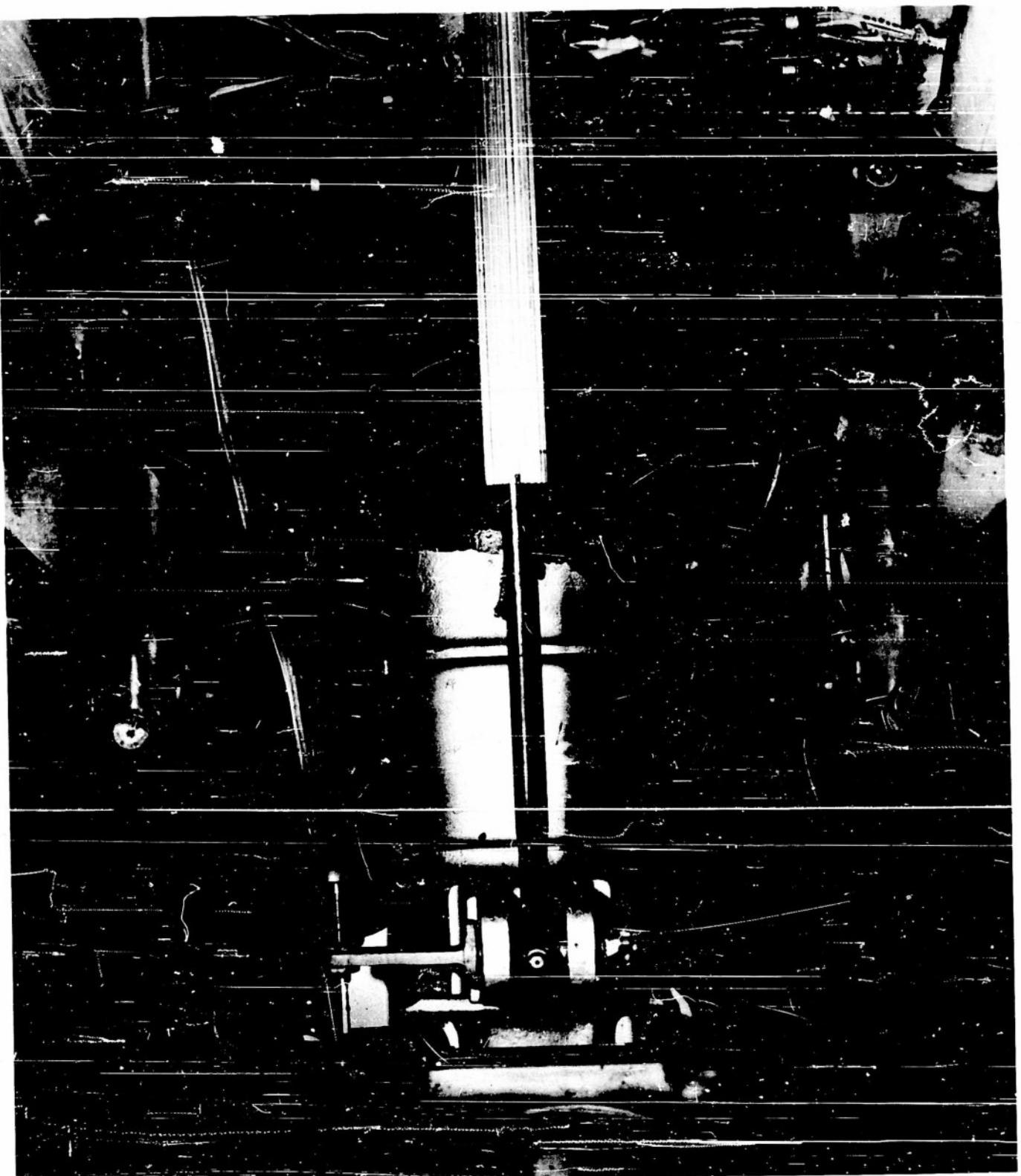
CONCLUSIONS

- a. The static heaviness indicator provides a direct visual reading of the static heaviness of an airship.
- b. It is estimated that errors should not exceed 2-1/2 percent of full scale under the still air conditions prevailing in a hangar.

8.

RECOMMENDATIONS

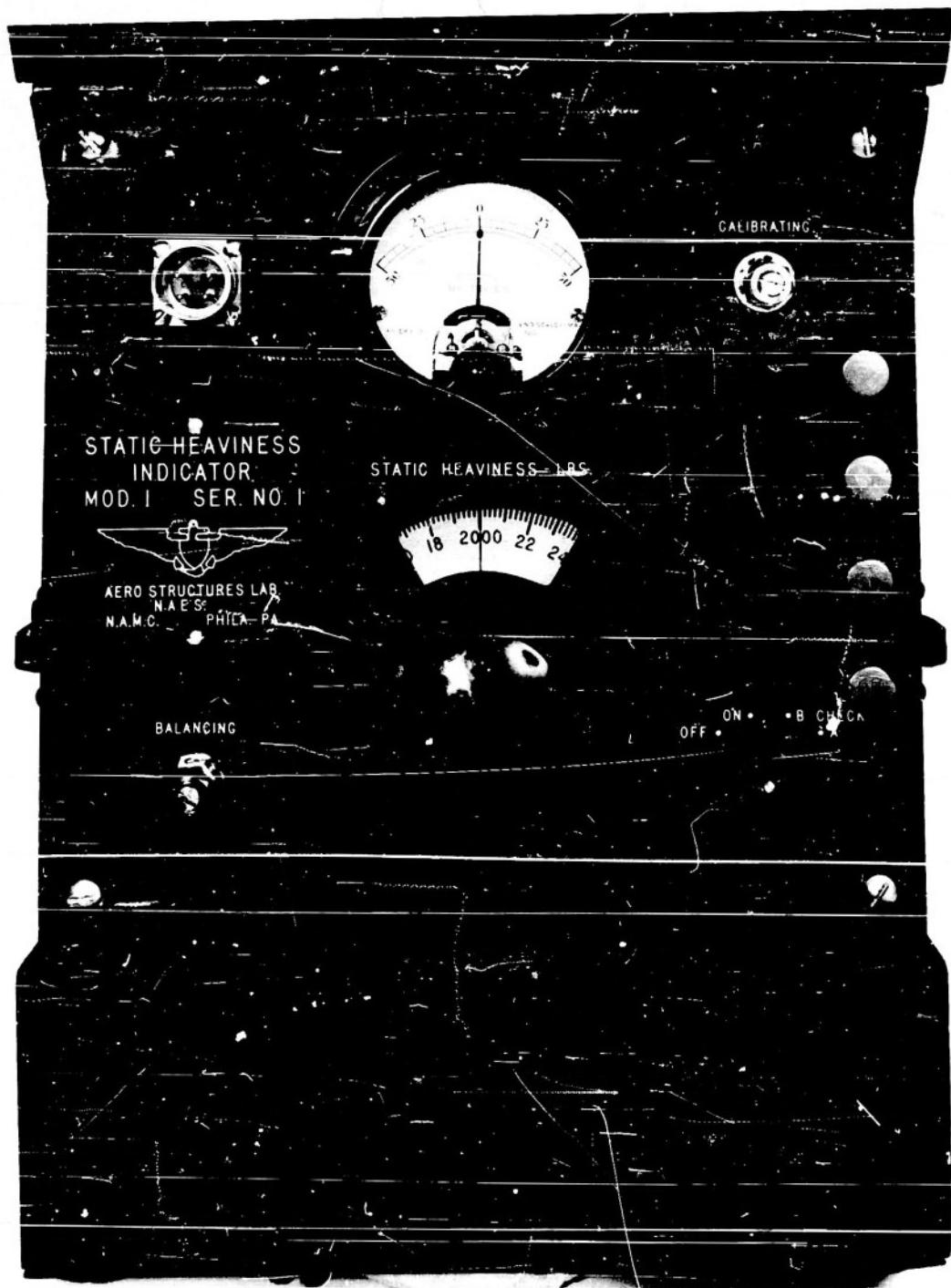
It is recommended that the equipment be evaluated for service use by the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, including tests under various wind conditions while the airship is masted outdoors.



COMPLETED STRAIN INSTALLATION ON TRUNNION OF LANDING GEAR

PHOTO: HAL6(1)-282918(L)-5-54

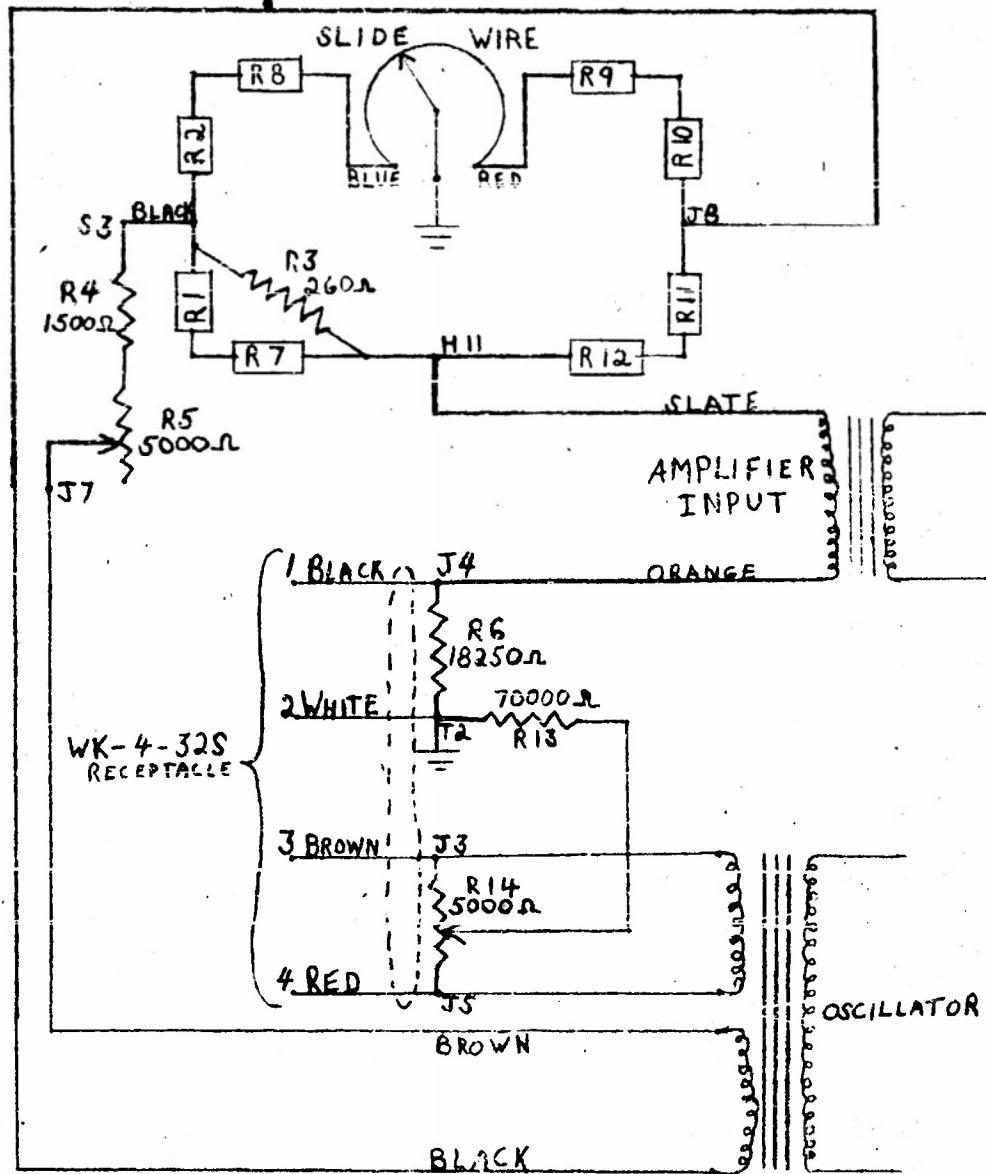
PLATE I



STATIC HEAVINESS INDICATOR

PHOTO: NAL6(1)-282390(1)-5-54

PLATE 2



Unchanged
 $R_1, R_2, R_{10}, R_{11} = 1.45 \Omega$
 $R_7, R_8, R_9, R_{12} = 10 \Omega$

Modifications
 $R_3 = 260 \Omega$ $R_6 = 18,250 \Omega$
 $R_4 = 1500 \Omega$ $R_{13} = 70,000 \Omega$
 $R_5 = 5000 \Omega$ calibrating pot. $R_{14} = 5,000 \Omega$ balancing pot.

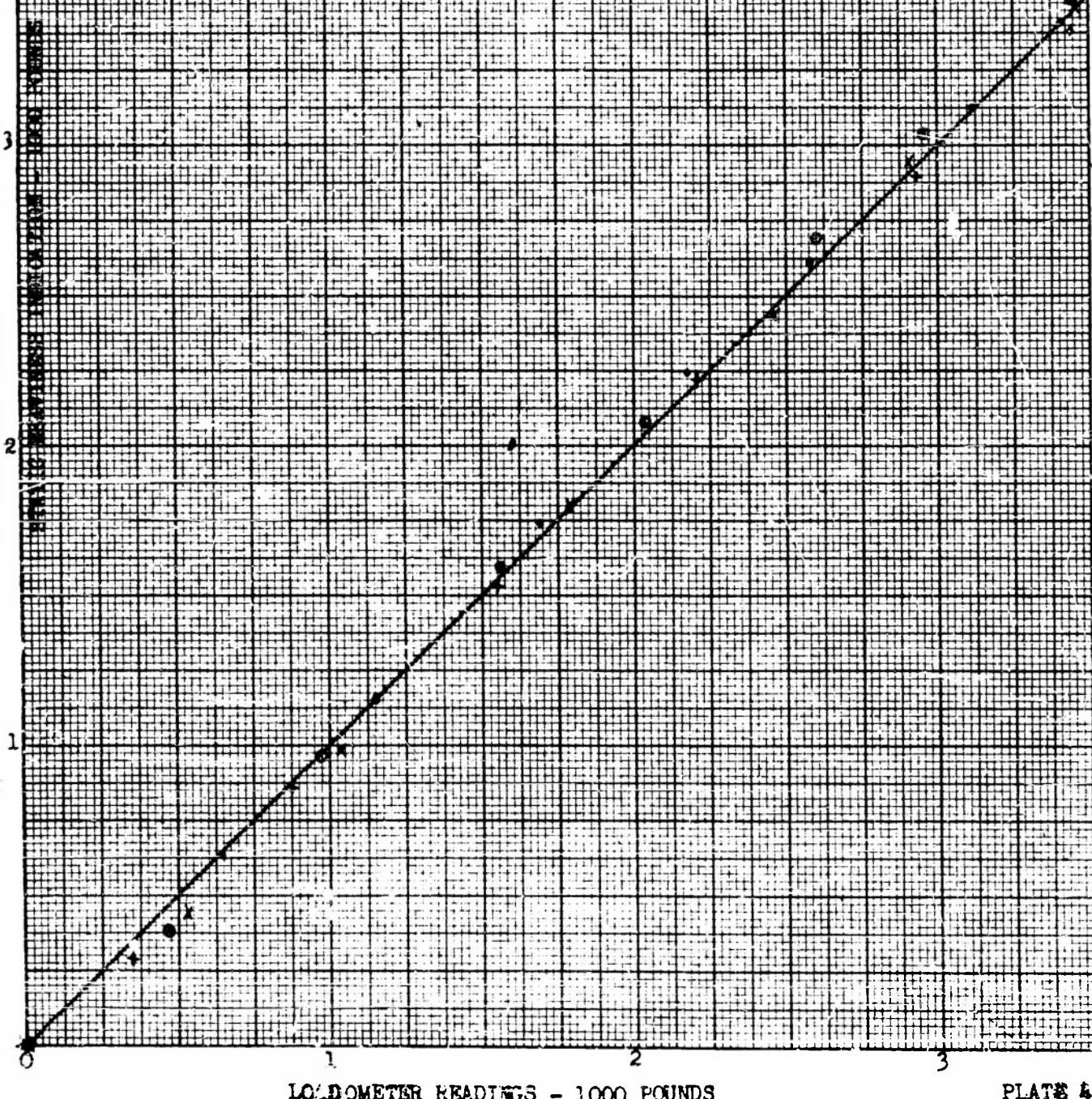
PORTION OF TYPE K SR-4 INDICATOR MODIFIED FOR
CONVERSION TO STATIC HEAVINESS INDICATOR

PLATE 5

CALIBRATION OF STATIC LOAD METER
ENDURANCE ON APPROXIMATE ATOMOSPHERE AT
LAKEWOOD, NEW JERSEY

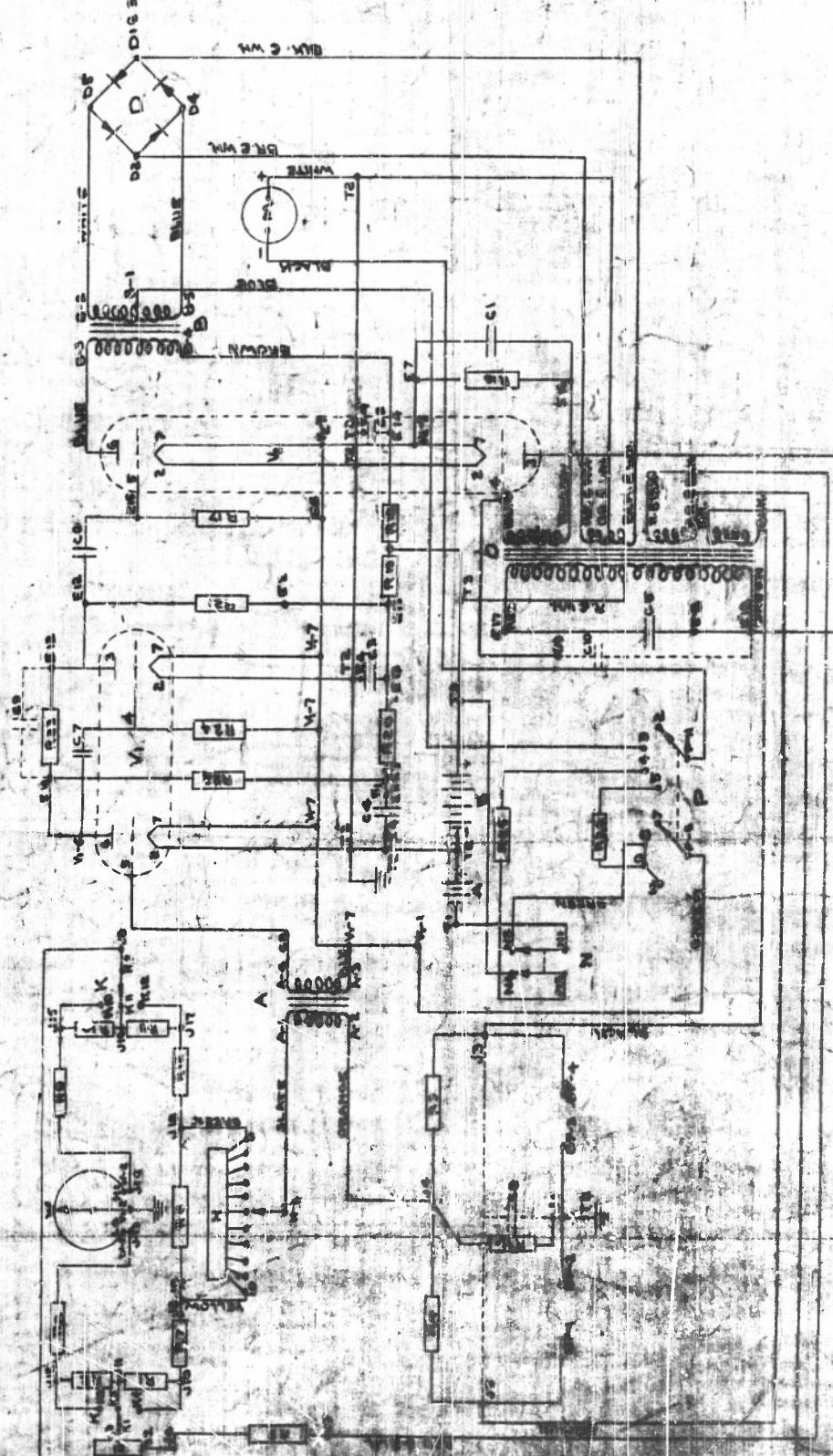
17 MAY 1954 □ Increasing
 ○ Decreasing

20 MAY 1954 ▲ Increasing
 × Decreasing



LEGEND FOR PORTABLE STRAIN INDICATOR

A - INPUT TRANSFORMER	R1 - 1A9GNS
B - OUTPUT TRANSFORMER	R2 - 1A9GNS
C - OSCILLATOR TRANSFORMER	R3 - 120 OHMS
D - RECTIFIER	R4 - 120 OHMS
E - RESISTOR AND CONDENSER PANEL ASNH.	R5 - 251 OHMS
F - BRIDGE RESISTOR PANEL ASNH.	R6 - 2500 OHMS OR THREE 100 OHMS
G - METER	R7 - 100 OHMS
H - PUSH BUTTON SWITCH	R8 - 15. OHMS
I - TUBES	R9 - 1/2. OHMS
J - CHECK SWITCH	R10-110 OHMS
K - REFERENCE SWITCH	R11-100 OHMS
L - GAGE FACTOR ADJUST	R12-10000 OHMS
M - BINDING POST	R13-100000 OHMS
N - RANGE EXTENDER SWITCH	R14-500 OHMS
O - SLIDEWIRE TERMINAL BOARD	R15-1.0 MFD.
P - TERMINAL STRIP	R16-0.1 MFD.
Q - .025 MFD.	R17-0.1 MFD.
R - .01 MFD.	R18-0.1 MFD.
S - .001 MFD.	R19-0.001 MFD.
T - .0001 MFD.	R20-0.0001 MFD.
U - .00001 MFD.	R21-0.00001 MFD.
V - .000001 MFD.	R22-0.000001 MFD.
W - .0000001 MFD.	R23-0.0000001 MFD.
X - .00000001 MFD.	R24-0.00000001 MFD.
Y - .000000001 MFD.	R25-0.000000001 MFD.
Z - .0000000001 MFD.	R26-0.0000000001 MFD.



QTY	REV. NO.	DATE	BY	PIECE NO.	REMARKS
1					ORIGINAL
1					DRAWN BY
1					TRACED BY
1					APPROVED BY
1					CHIEF ENGINEER
1					APPROVED
1					FUNCTIONAL DIMENSIONS ARE +1/2"

BALDWIN SOUTHWAHK DIVISION
THE BALDWIN LOCOMOTIVE WORKS
SCOTTSWOOD DEPT.

TYPE K SR-4
STRAIN INDICATOR

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